

## Patent Abstracts of Japan

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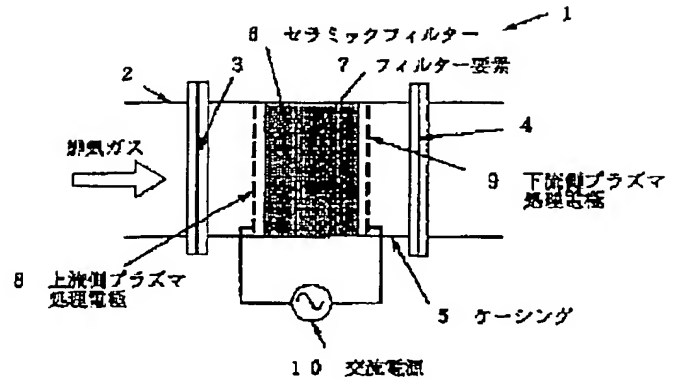
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TITLE : DIESEL ENGINE EXHAUST GAS  
PURIFYING DEVICE



ABSTRACT : PURPOSE: To improve purifying efficiency for exhaust gas while preventing increase of pressure loss caused by adhesion of soot and lowering of engine efficiency by applying oxidation decomposition to soot stuck on the filter element of a collective ceramic filter by plasma treatment.

CONSTITUTION: A casing 5 having the inlet 3 of exhaust gas and the outlet 4 of purifying gas is connected to the exhaust duct 2 of a diesel engine. A ceramic filter 6 is arranged inside the casing 5, and also plasma treatment electrodes 8, 9 are arranged respectively in vertical direction in a filter element 7. Discharge interposed the filter element 7 as dielectric is generated by applying a high frequency voltage and the like from A.C. power supply between each plasma treatment electrode 8, 9. And plasma and radical which is rich to reaction of oxidizing performance and reducing performance are generated in association with discharging so as to discharge soot stuck on the filter element 7 as CO<sub>2</sub> or CO.

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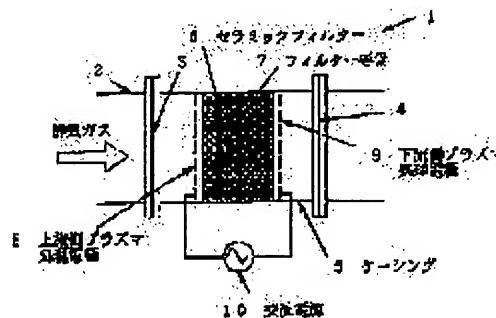
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HOSOKAWA SHUNSUKE

## (54) DIESEL ENGINE EXHAUST GAS PURIFYING DEVICE

(57)Abstract:

PURPOSE: To improve purifying efficiency for exhaust gas while preventing increase of pressure loss caused by adhesion of soot and lowering of engine efficiency by applying oxidation decomposition to soot stuck on the filter element of a collective ceramic filter by plasma treatment.

CONSTITUTION: A casing 5 having the inlet 3 of exhaust gas and the outlet 4 of purifying gas is connected to the exhaust duct 2 of a diesel engine. A ceramic filter 6 is arranged inside the casing 5, and also plasma treatment electrodes 8, 9 are arranged respectively in vertical direction in a filter element 7. Discharge interposed the filter element 7 as dielectric is generated by applying a high frequency voltage and the like from A.C. power supply between each plasma treatment electrode 8, 9. And plasma and radical which is rich to reaction of oxidizing performance and reducing performance are generated in association with discharging so as to discharge soot stuck on the filter element 7 as CO<sub>2</sub> or CO.



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## CLAIMS

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### [Claim(s)]

[Claim 1] Form the ceramic filter which consists of a filter element of a porosity ceramic in the interior of casing which has the inlet port of exhaust gas and the outlet of clarification gas containing soot so that a gas stream may be interrupted, and it pinches this filter element. It arranges after insulating mutually 2 sets of the plasma treatment electrode which consists of at least one electrode element of the structure which does not bar the flow of gas. The diesel-power-plant exhaust gas purge characterized by preparing the AC power supply for connecting with both this plasma treatment electrode, and impressing alternating voltage between them, and making both plasma treatment inter-electrode generate discharge through the at least 1 section of this filter element.

[Claim 2] The diesel-power-plant exhaust gas purge according to claim 1 characterized by consisting of the electrode element of either the wire gauze at which both the above-mentioned plasma treatment electrode approached the above-mentioned ceramic filter, and was prepared in the upstream and downstream thru/or a perforated plate.

[Claim 3] While this ceramic filter consists of many long and slender gas-passageway groups by honeycomb structure It is blockaded in the lock out section which the upper edge and down-stream edge of the gas passageway become from a ceramic by turns. It is divided into the upstream gas-passageway group which was open for free passage to the upstream, and the downstream gas-passageway group which was open for free passage to the downstream. A diesel-power-plant exhaust gas purge given in any 1 term of claims 1 or 2 characterized by being the honeycomb mold ceramic filter with which the septum between the \*\*\*\*\* ring main path constituted the above-mentioned filter element.

[Claim 4] It is exhaust air gas cleanup \*\*\*\* of the diesel power plant according to claim 3 characterized by for that [ one ] consisting of the electrode element of either the wire gauze formed in this by approaching at the upstream of the lock out edge of the above-mentioned honeycomb mold ceramic filter thru/or a perforated plate, and consisting of the wire-like electrode element with which another side was inserted from the downstream to the back at this downstream gas-passageway group of the above-mentioned honeycomb mold ceramic filter among the 2 above-mentioned sets of plasma treatment electrodes.

[Claim 5] The exhaust gas purge of the diesel power plant according to claim 3 characterized by consisting of the electrode element of the shape of a wire arranged so that one side might be located near the inlet port of the upstream gas-passageway group of the above-mentioned honeycomb mold ceramic filter in a downstream point among the 2 above-mentioned sets of plasma treatment electrodes, and consisting of the wire-like electrode element with which another side was inserted from the downstream into this downstream gas-passageway group.

[Claim 6] It consists of an electrode element of the shape of a wire arranged so that one side might be located near [ each ] the inlet port of this upstream gas-passageway group of the above-mentioned honeycomb mold ceramic filter in a downstream point among the 2 above-mentioned sets of plasma treatment electrodes. It consists of the wire-like electrode element with which another side was inserted in this downstream gas-passageway group from the downstream. And the exhaust gas purge of the diesel power plant according to claim 5 characterized by establishing an insertion / extract means to insert and extract the wire-like electrode element of this upstream processing electrode from the inlet port of this upstream gas passageway where the head counters, respectively to in this gas passageway.

[Claim 7] The exhaust gas purge of the diesel power plant according to claim 3 characterized by consisting of the wire-like electrode element with which one side was inserted from the upstream to the back among the 2 above-mentioned sets of plasma treatment electrodes into this upstream gas-passageway group of the above-mentioned honeycomb mold ceramic filter, and consisting of the wire-like electrode element with which another side was inserted from the downstream to the back into this downstream gas-passageway group.

[Claim 8] The exhaust gas purge of the diesel power plant according to claim 3 characterized by carrying out opposite arrangement of the electrode element of each other which consists of the wire-like electrode element with which the both sides of the 2 above-mentioned sets of plasma treatment electrodes were inserted from the downstream into this

downstream gas-passageway group, and belongs to the plasma treatment electrode of both groups through the one above-mentioned upstream gas passageway.

[Claim 9] The exhaust gas purge of a diesel power plant given in any 1 term of claims 1-8 characterized by \*\*\*\* whose above-mentioned AC power supply is a RF high voltage power supply which generates the output voltage peak value of 3kV or more, and RF high tension with an output frequency of 5kHz or more.

[Claim 10] The exhaust gas purge of a diesel power plant given in any 1 term of claims 1-8 characterized by \*\*\*\* whose above-mentioned AC power supply is a high voltage pulse power source which generates the output voltage peak value of 5kV or more, and pulse-like high tension with an output frequency of 50Hz or more.

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention by carrying out low temperature oxidation of the soot by which uptake was carried out, and gasifying it by the discharge plasma, at the same time it carries out uptake of the soot contained in combustion exhaust gas, especially the exhaust gas from a diesel power plant efficiently using a ceramic filter. In an operation of the radical which prevents clogging of this ceramic filter, and prevents the increment in the pressure loss of the filter produced with soot, and the above-mentioned plasma generates, it oxidizes thru/or returns, gaseous pollutants, such as NO<sub>x</sub> in this exhaust gas, are also removed, and it is related with the equipment which prevents air pollution.

[0002]

[Description of the Prior Art] When carrying out uptake of the soot in the exhaust gas of a diesel power plant using a ceramic filter conventionally, with the soot which carried out uptake, a lifting and its pressure loss are remarkable in a short time, a filter will increase clogging, and engine effectiveness will fall.

[0003] Therefore, the burner was put on the upstream of a ceramic filter, or the heater was put into the ceramic filter itself, the soot which carried out uptake was gasified by combustion, and clogging is prevented.

[0004] However, it is difficult to burn homogeneity in this case, and into the part which burned first, an inflow and the amount of supply oxygen will increase [ more gas ], its rate of combustion will increase by ventilation resistance reduction, and much gas will flow increasingly. As a result, superfluous heat of combustion occurred in the part there, abnormality lifting of temperature took place, the ceramic filter was worn out, and the life was shortened remarkably.

[0005] Moreover, the method of the exhaust gas of a diesel power plant being and using a catalyst for clearance of NO<sub>x</sub> which is the problem of a paralysis convex is taken.

[0006] However, the efficient and long lasting NO<sub>x</sub> clearance catalyst over the diesel-power-plant exhaust air containing soot was not yet completed, but when the ceramic filter for the account soot uptake of very best and catalyst were used for the duplex, the pressure loss of an exhaust side increased increasingly, and the decline in engine efficiency was not avoided.

[0007]

[Problem(s) to be Solved by the Invention] The object of this invention is always preventing that clogging without overheating and breakage on a filter by oxidizing uniformly the soot by which uptake was carried out to the ceramic filter for soot uptake at low temperature.

[0008] Moreover, other objects are removing simultaneously the gaseous pollutant in exhaust gas, especially NO<sub>x</sub>.

[0009]

[Means for Solving the Problem] The diesel-power-plant exhaust gas purge of this invention Connect with the exhaust duct of a diesel power plant, and casing which has the inlet port of exhaust gas and the outlet of clarification gas containing soot is prepared. Form a ceramic filter so that a gas stream may be interrupted to the interior, and the filter element of this ceramic filter is pinched. It arranges after insulating mutually 2 sets of the plasma treatment electrode which consists of at least one electrode element of the structure which does not bar the flow of gas. The AC power supply for connecting with both this plasma treatment electrode, and impressing alternating voltage between them is prepared, and it makes both plasma treatment inter-electrode generate discharge through the at least 1 section of this filter element.

[0010] In this case, both the above-mentioned plasma treatment electrode approaches the above-mentioned ceramic filter, and prepares and constitutes the electrode element of a wire gauze thru/or a perforated plate in that upstream and downstream.

[0011] Moreover, it is divided into the upstream gas-passageway group which it was blockaded by turns and the upper

edge and down-stream edge of this gas passageway opened for free passage to the upstream as the above-mentioned ceramic filter while consisting of many long and slender gas-passageway groups by honeycomb structure, and the downstream gas-passageway group which was open for free passage to the downstream if needed. While using the honeycomb mold ceramic filter with which the septum between the \*\*\*\*\* ring main path constitutes the above-mentioned filter element An upstream electrode is constituted from an electrode element of either the wire gauze formed in the upstream of the lock out edge of the above-mentioned honeycomb mold ceramic filter by approaching with this thru/or a perforated plate among the 2 above-mentioned sets of plasma treatment electrodes. Moreover, a downstream electrode consists of wire-like electrode elements inserted in this downstream gas-passageway group of the above-mentioned honeycomb mold ceramic filter from the downstream.

[0012] Or an upstream processing electrode is carried out among the 2 above-mentioned sets of plasma treatment electrodes in this case as [ locate / that downstream point / carry out the arrangement configuration of the wire-like electrode element, and / at the upstream of the above-mentioned honeycomb mold ceramic filter / near the inlet port of this upstream gas-passageway group ], and a downstream processing electrode inserts and constitutes a wire-like electrode element from the downstream in this downstream gas-passageway group.

[0013] In this case, insertion / extract means for inserting and extracting the wire-like electrode element of the above-mentioned upstream polar zone from the inlet port of this upstream gas passageway where that head counters, respectively to in this gas passageway if needed is established.

[0014] or it constitutes from a wire-like electrode element which boiled the upstream processing electrode among the 2 above-mentioned sets of plasma treatment electrodes if needed in this upstream gas-passageway group of the above-mentioned honeycomb mold ceramic filter, and was inserted from the upstream, and a downstream processing electrode consists of wire-like electrode elements inserted from the downstream into this downstream gas-passageway group.

[0015] Or it is made for the electrode element which inserts a wire-like electrode element, and constitutes the both sides of the 2 above-mentioned sets of plasma treatment electrodes from the downstream in this downstream gas-passageway group if needed, and belongs to the plasma treatment electrode of the both sides to counter through one upstream gas passageway mutually.

[0016] Moreover, as the above-mentioned AC power supply, the peak value of output voltage is an object using the RF high voltage power supply which generates 3kV or more and RF high tension with an output frequency of 5kHz or more.

[0017] Or the high voltage pulse power source which generates the output voltage peak value of 5kV or more and pulse-like high tension with an output frequency of 50Hz or more as the above-mentioned AC power supply is used if needed.

[0018]

[Function] Discharge is generated through the filter element to which alternating voltage was impressed continuously or intermittently among the 2 above-mentioned sets of plasma treatment electrodes, and the soot of a ceramic filter adhered. By carrying out low temperature oxidation of the soot by the radical generated in a plasma chemistry operation of this discharge, it gasifies and removes and clogging of the above-mentioned filter element with soot is prevented. By this, the pressure loss of this ceramic filter is always kept low, and the degradation of a diesel power plant is prevented.

[0019] In an operation of the above-mentioned radical, it oxidizes or returns, gaseous pollutants, such as NOx contained in exhaust gas, are also removed simultaneously, and the exhaust gas of a diesel power plant is purified.

[0020]

[Example] Drawing 1 shows drawing of longitudinal section of an example 1 showing the fundamental concept of this invention. A ceramic filter 6 is arranged so that a gas stream may be interrupted inside the casing 5 which intervened in the exhaust duct 2 of a diesel power plant, and connected the gas inlet 3 and the gas outlet 4. however, the shape of tabular [ to which this ceramic filter 6 uses a porosity ceramic as a filter element ], the letter of a pleat, and a honeycomb and cylindrical \*\* -- the general ceramic filter of all suitable configuration and structures is shown typically.

[0021] The upstream plasma treatment electrode 8 and the downstream plasma treatment electrode 9 which consist of electrode elements (for example, a wire gauze, a metal perforated plate, metal blind, etc.) of the structure of allowing passage of gas the upstream and the downstream of the filter element 7 of this ceramic filter 6 are prepared, and RF high tension or a high voltage pulse voltage is impressed continuously or intermittently between them than AC power supply 10.

[0022] As a result, the discharge between which the above-mentioned filter element 7 was made to be placed as a dielectric among both the plasma treatment electrodes 8 and 9 occurs. This discharge takes the gestalt of silent discharge and void discharge all over the opening inside [ filter element 7 ] this in the gas space between these plasma treatment electrodes 8 and 9 and the front face of this filter element 7, and although all of electron temperature are very high, ionic

temperature generates the low low-temperature plasma (it is also called nonequilibrium plasma), and makes to abundance the radical which is rich in the reactivity of an oxidizing quality and reducibility.

[0023] Low temperature oxidation of the soot which adhered to the inlet face and internal opening of the above-mentioned filter element 7 by this radical is carried out, it is discharged as CO<sub>2</sub> thru/or CO, and as a result, the filter element 7 of the above-mentioned ceramic filter 6 is always maintained at clarification, and can keep pressure loss low. Simultaneously, it is oxidized thru/or returned and gaseous pollutants, such as NO<sub>x</sub> in exhaust gas, are removed by this radical.

[0024] The perspective view of the honeycomb mold ceramic filter 11 which already described drawing 2, and drawing 3 are drawings of longitudinal section of the body of an example 12 which carried out this invention using this. This filter has honeycomb structure and has the long and slender gas-passageway group 14 of a large number separated by the porosity ceramic septum 13.

[0025] These gas-passageway groups 14 are divided into the upstream gas-passageway group 17 which is open for free passage to the upstream and by which it was blockaded by adjacency \*\*\*\*\* in the upper edge and down-stream edge by the lock out section 15 made from an upstream ceramic, and the lock out section 16 made from a downstream ceramic, and the down-stream edge was blockaded, and the downstream gas-passageway group 18 which is open for free passage to the downstream and by which the upstream was blockaded.

[0026] And exhaust gas advances from the upstream opening 19 into this upstream gas-passageway group 17, passes this porosity ceramic septum 13 that constitutes the above-mentioned filter element 7, enters in this downstream gas-passageway group 18, and is discharged from the downstream opening 20. Soot adheres all over the internal opening with the inlet face of this ceramic septum 13.

[0027] 8 is an upstream plasma treatment electrode which uses as an electrode element the wire gauze 21 which approached the upstream of the above-mentioned lock out section 14 made from an upstream ceramic with this, and was formed in it. Moreover, 9 is a downstream plasma treatment electrode which uses as an electrode element the wire 22 inserted from the downstream opening 20 to the back into the above-mentioned downstream gas-passageway group 18.

[0028] If RF high tension or a high voltage pulse voltage is now impressed continuously or intermittently from AC power supply 10 among both the plasma treatment electrodes 8 and 9 Intervene the about 19 upstream opening parts of the above-mentioned lock out section 15 made from an upstream ceramic which is a dielectric, and this ceramic septum 13 between the upstream point 23 of this wire electrode element 22, and this wire gauze electrode element 22, and silent discharge occurs. The radical which this generated advances into each upstream gas-passageway group 17 from this upstream opening 19, low temperature oxidation of the soot which adhered all over the inlet face and internal gap of this ceramic septum 13 is carried out, and it is removed. Moreover, gaseous pollutants including NO<sub>x</sub> in exhaust gas are oxidized and returned, and are removed.

[0029] Drawing 4 is drawing of longitudinal section of the body of a different example 24 from drawing 3 of this invention, the upstream plasma treatment electrode 8 consists of a wire electrode element 25 in this example, and the downstream point 26 is located near the opening core of the above-mentioned upstream opening 19. The names and functions of an element from 12 to the other 23 are the same as that of the element of the same number in the example 12 of drawing 3.

[0030] If the above-mentioned alternating voltage is impressed from AC power supply 10 among two electrodes 8 and 9, silent discharge occurs between this upstream point 26 and the downstream point 23, oxidation of soot will start first in generation and the upstream opening 19 neighborhood, and a radical will reach the interior of the upstream gas passageway 17 serially. In order to help the operation, if there is an insertion / extract means to insert in the interior of the above-mentioned upstream gas passageway 17 this wire electrode element of the plasma treatment electrode 8 which is not shown in drawing, and to extract it, and this upstream point 26 is serially advanced with progress of oxidation clearance of soot and clearance of soot divides, this will be extracted in the location of a basis.

[0031] In addition, it is as having already described that gaseous pollutants including NO<sub>x</sub> are also removed in an operation of a radical in this case.

[0032] Drawing 5 is drawing of longitudinal section of the body of a different example 27 from drawing 3 of this invention, and drawing 4, and the upstream plasma treatment electrode 8 consists of a wire electrode element 25 like drawing 4. However, in this example, this wire electrode element 25 is inserted from the upstream to the back into this upstream gas-passageway group 17, and has countered through the wire electrode element 22 and this porosity septum 13 of the downstream plasma treatment electrode 9 which were inserted from the downstream to the back into this downstream gas-passageway group 18. The names and functions of an element from 8 to the other 25 are the same as that of the element of the same number in the examples 12 and 24 of drawing 3 and drawing 4.

[0033] When the above-mentioned alternating voltage is now supplied from AC power supply 10 among two electrodes

8 and 9, it is as having already described that discharge occurs through this porosity septum 13 between both the above-mentioned wire electrode element 22 and 25, and the soot which adhered in the inlet face of this septum and the internal opening is removed, and gaseous pollutants including NOx are also removed.

[0034] Drawing 6 is drawing of longitudinal section of the body of a different example 28 from drawing 3 of this invention, drawing 4, and drawing 4. this example -- any of 2 sets of plasma treatment electrodes 9 and 29 -- although - it consisted of wire electrode elements 22 and 30 inserted from the downstream to the back into this downstream gas-passageway group 18, and both the wire electrode elements 22 and 30 have countered in the medium through this porosity ceramic septum 13 of one upstream gas passageway 14 and its both sides, respectively. the names and functions of an element from 9 to the other 22 -- drawing 3 and drawing 4 -- it is the same as that of the element of the same number in the examples 12, 24, and 28 to call.

[0035] When the above-mentioned alternating voltage is now impressed from AC power supply 10 among both the plasma treatment electrodes 9 and 29, it is as above-mentioned that silent discharge occurs through this porosity ceramic septum 13 of this upstream gas passageway 14 inserted into these and its both sides, and soot and a gaseous pollutant are removed among both the above-mentioned wire electrode elements 22 and 30.

[0036]

[Effect] Since this invention is as above-mentioned, oxidization decomposition of the soot adhering to the inlet face and internal opening of a filter element of a ceramic filter is always carried out by the plasma treatment by discharge, lifting by soot adhesion of the pressure loss can be prevented, and the degradation of a diesel power plant can be prevented, and the life of a ceramic filter can be maintained for a long time.

[0037] Moreover, gaseous pollutants including NOx simultaneously contained in diesel-power-plant exhaust gas can be oxidized and returned by plasma treatment, this can be removed, and clarification of very economical diesel-power-plant exhaust gas can be attained.

[0038]

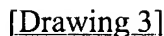
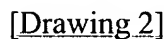
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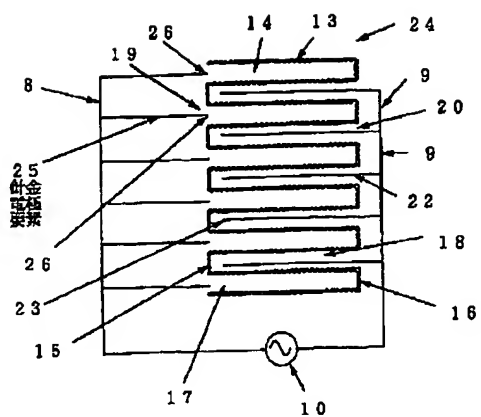
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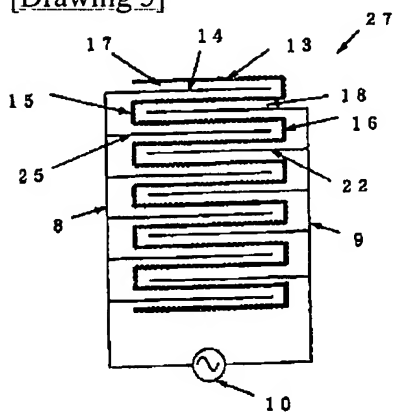
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[Drawing 1]

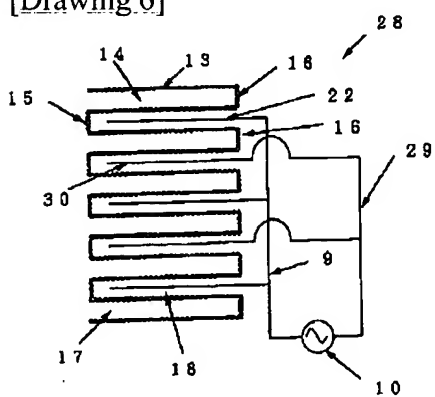




[Drawing 5]



[Drawing 6]



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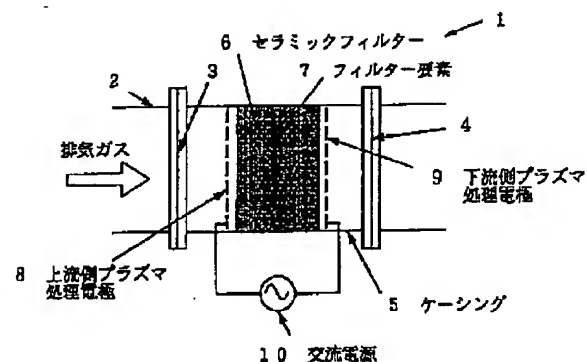
群馬県太田市富沢383、富沢団地14の13号

(54) 【発明の名称】 デーゼルエンジン排気ガス浄化装置

(57) 【要約】

【目的】 デーゼルエンジン等からの排気ガスのすすを捕集するセラミックフィルターにおいて、付着したすすを常時プラズマによる低温酸化で取り除いて、圧力損失の上昇とエンジン効率の低下を防ぐ。あわせてプラズマの作用で排気ガス中のNO<sub>x</sub>等のガス状汚染物質を除去する。

【構成】 セラミックフィルターのフィルター要素を挟んで2組のプラズマ処理電極を設け、その間に高周波高電圧またはパルス高電圧等の交流電圧を印加して放電を発生させる。この放電で生成したラジカルによってフィルター要素の上流側表面と内部空隙に付着したすすを低温酸化する。またこのラジカルで排気ガス中のNO<sub>x</sub>等のガス状汚染物質を酸化・還元して除去する。



## 【特許請求の範囲】

【請求項1】 すすを含んだ排気ガスの入口と清浄ガスの出口を有するケーシングの内部に、ガス流を遮る如くに多孔質セラミックのフィルター要素よりなるセラミックフィルターを設け、該フィルター要素を挟んで、ガスの流れを妨げない構造の少なくとも1つの電極要素からなるプラズマ処理電極の2組を相互に絶縁のうえ配設し、この両プラズマ処理電極に接続してその間に交流電圧を印加するための交流電源を設け、該フィルター要素の少なくとも1部を介して両プラズマ処理電極間に放電を発生させる事の特徴とするディーゼルエンジン排気ガス浄化装置。

【請求項2】 上記の両プラズマ処理電極が上記セラミックフィルターに近接して、その上流側と下流側に設けられた金網ないし多孔板のいずれかの電極要素から成る事の特徴とする請求項1に記載のディーゼルエンジン排気ガス浄化装置。

【請求項3】 該セラミックフィルターがハニカム構造で多数の細長いガス通路群より成ると共に、そのガス通路の上流端と下流端が交互にセラミックよりなる閉塞部で閉塞されて、上流側に連通した上流側ガス通路群と下流側に連通した下流側ガス通路群に分かれ、その隣合う両ガス通路の間の隔壁が上記フィルター要素を構成した、ハニカム型セラミックフィルターである事の特徴とする請求項1または2のいずれか1項に記載のディーゼルエンジン排気ガス浄化装置。

【請求項4】 上記2組のプラズマ処理電極のうち、一方が上記ハニカム型セラミックフィルターの閉塞端の上流側に、これに近接して設けられた金網ないし多孔板のいずれかの電極要素から成り、他方が上記ハニカム型セラミックフィルターの該下流側ガス通路群に下流側から奥まで挿入された針金状の電極要素から成る事の特徴とする請求項3に記載のディーゼルエンジンの排気ガス浄化装置。

【請求項5】 上記2組のプラズマ処理電極のうち、一方が上記ハニカム型セラミックフィルターの上流側ガス通路群の入口付近に下流側先端部を位置する如くに配設された針金状の電極要素から成り、他方が該下流側ガス通路群内に下流側から挿入された針金状の電極要素から成る事の特徴とする請求項3に記載のディーゼルエンジンの排気ガス浄化装置。

【請求項6】 上記2組のプラズマ処理電極のうち、一方が上記ハニカム型セラミックフィルターの該上流側ガス通路群のそれぞれの入口付近に下流側先端部を位置する如くに配設された針金状の電極要素からなり、他方が該下流側ガス通路群に下流側から挿入された針金状の電極要素から成り、かつ該上流側処理電極の針金状電極要素をそれぞれその先端が対向する該上流側ガス通路の入口から該ガス通路内に挿入・抽出する挿入・抽出手段を設けた事の特徴とする請求項5に記載のディーゼルエ

ンジンの排気ガス浄化装置。

【請求項7】 上記2組のプラズマ処理電極のうち、一方が上記ハニカム型セラミックフィルターの該上流側ガス通路群内に上流側から奥まで挿入された針金状の電極要素から成り、他方が該下流側ガス通路群内に下流側から奥まで挿入された針金状の電極要素から成る事の特徴とする請求項3に記載のディーゼルエンジンの排気ガス浄化装置。

【請求項8】 上記2組のプラズマ処理電極の双方が該下流側ガス通路群内に下流側から挿入された針金状の電極要素から成り、かつ両組のプラズマ処理電極に属する電極要素が互いに1つの上記上流側ガス通路を介して対向配設された事の特徴とする請求項3に記載のディーゼルエンジンの排気ガス浄化装置。

【請求項9】 上記の交流電源が出力電圧波高値3kV以上、出力周波数5kHz以上の高周波高電圧を発生する高周波高圧電源である事の特徴とする請求項1～8のいずれか1項に記載のディーゼルエンジンの排気ガス浄化装置。

【請求項10】 上記の交流電源が出力電圧波高値5kV以上、出力周波数50Hz以上のパルス状高電圧を発生する高圧パルス電源である事の特徴とする請求項1～8のいずれか1項に記載のディーゼルエンジンの排気ガス浄化装置。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】この発明は、燃焼排気ガス、特にディーゼルエンジンからの排気ガス中に含まれるすすをセラミックフィルターを用いて効率良く捕集すると同時に、捕集されたすすを放電プラズマによって低温酸化しガス化する事により、該セラミックフィルターの目詰りを防止し、すすで生ずるフィルターの圧力損失の増加を防止し、かつ上記プラズマが生成するラジカル作用で該排気ガス中のNO<sub>x</sub>などのガス状汚染物質も酸化ないし還元して除去し、大気汚染を防止する装置に関するものである。

## 【0002】

【従来の技術】従来セラミックフィルターを用いてディーゼルエンジンの排気ガス中のすすを捕集する場合、捕集した煤によってフィルターが目詰りを起こし、その圧力損失が短時間で著しく増加してエンジンの効率が低下してしまう。

【0003】そのためセラミックフィルターの上流側にバーナーを置いたり、セラミックフィルター自体にヒーターを入れて、捕集したすすを燃焼によりガス化し、目詰りを防止している。

【0004】しかしながら、この場合均一に燃焼させることは困難で、はじめに燃焼した部分に通気抵抗減少により、より多くのガスが流入、供給酸素量が増大して燃焼速度が増し、ますます多くのガスが流入することとな

る。その結果その部分で過剰な燃焼熱が発生して温度の異常上昇が起こり、セラミックフィルターが損耗し、その寿命を著しく短縮していた。

【0005】またディーゼルエンジンの排気ガスのいまひとつの問題である $\text{NO}_x$ の除去には触媒を用いる方法が取られている。

【0006】しかしながら、すすを含むディーゼルエンジン排気に対する高効率かつ長寿命の $\text{NO}_x$ 除去触媒は未だ完成されておらず、その上上記すす捕集用セラミックフィルターと触媒を2重に用いると排気側の圧力損失はますます増加し、エンジン効率の低下は避けられなかった。

【0007】

【発明が解決しようとする課題】この発明の目的は、すす捕集用セラミックフィルターに捕集されたすすを均一に且つ低温で酸化する事によりフィルターの過熱・損傷なしにその目詰りを常に防止することである。

【0008】また他の目的は、排気ガス中のガス状汚染物質、特に $\text{NO}_x$ を同時に除去することである。

【0009】

【問題を解決するための手段】この発明のディーゼルエンジン排気ガス浄化装置は、ディーゼルエンジンの排気ダクトに接続して、すすを含んだ排気ガスの入口と清浄ガスの出口を有するケーシングを設け、その内部にガス流を遮る如くにセラミックフィルターを設け、該セラミックフィルターのフィルター要素を挟んで、ガスの流れを妨げない構造の少なくとも1つの電極要素からなるプラズマ処理電極の2組を相互に絶縁のうえ配設し、この両プラズマ処理電極に接続してその間に交流電圧を印加するための交流電源を設け、該フィルター要素の少なくとも1部を介して両プラズマ処理電極間に放電を発生させるものである。

【0010】この場合、上記の両プラズマ処理電極は上記セラミックフィルターに近接して、その上流側と下流側に金網ないし多孔板の電極要素を設けて構成するものである。

【0011】また必要に応じて、上記セラミックフィルターとして、ハニカム構造で多数の細長いガス通路群より成ると共に該ガス通路の上流端と下流端が交互に閉塞されて上流側に連通した上流側ガス通路群と下流側に連通した下流側ガス通路群に分かれ、その隣合う両ガス通路の間の隔壁が上記フィルター要素を構成するハニカム型セラミックフィルターを用いると共に、上記2組のプラズマ処理電極のうち、上流側電極は上記ハニカム型セラミックフィルターの閉塞端の上流側にこれと近接して設けられた金網ないし多孔板のいずれかの電極要素から構成し、また下流側電極は上記ハニカム型セラミックフィルターの該下流側ガス通路群に下流側から挿入された針金状の電極要素から構成するものである。

【0012】あるいは、この場合上記2組のプラズマ処

理電極のうち、上流側処理電極は上記ハニカム型セラミックフィルターの上流側に針金状の電極要素を配設構成してその下流側先端部が該上流側ガス通路群の入口付近に位置する如くし、また下流側処理電極は該下流側ガス通路群内に下流側から針金状の電極要素を挿入して構成するものである。

【0013】この場合、必要に応じて上記上流側電極部の針金状電極要素をそれぞれその先端が対向する該上流側ガス通路の入口から該ガス通路内に挿入・抽出するための挿入・抽出手段を設けるものである。

【0014】あるいは必要に応じて上記2組のプラズマ処理電極のうち、上流側処理電極は上記ハニカム型セラミックフィルターの該上流側ガス通路群内に上流側から挿入された針金状の電極要素で構成し、また下流側処理電極は該下流側ガス通路群内に下流側から挿入された針金状の電極要素で構成するものである。

【0015】あるいは必要に応じて上記2組のプラズマ処理電極の双方を、該下流側ガス通路群内に下流側から針金状の電極要素を挿入して構成し、かつその双方のプラズマ処理電極に属する電極要素が互いに1つの上流側ガス通路を介して対向する様にするものである。

【0016】また上記の交流電源としては出力電圧の波高値が3kV以上、出力周波数5kHz以上の高周波高電圧を発生する高周波高圧電源を用いる物である。

【0017】あるいは必要に応じて、上記の交流電源としては出力電圧波高値5kV以上、出力周波数50Hz以上のパルス状高電圧を発生する高圧パルス電源を用いるものである。

【0018】

【作用】上記2組のプラズマ処理電極の間に交流電圧を連続的または間欠的に印加してセラミックフィルターのすすが付着したフィルター要素を介して放電を発生させる。この放電のプラズマ化学作用で生成するラジカルによりすすを低温酸化することによりガス化して除去し、すすによる上記フィルター要素の目詰りを防ぐ。これによって該セラミックフィルターの圧力損失を常に低く保ち、ディーゼルエンジンの効率低下を防止する。

【0019】上記ラジカル作用で、排気ガス中に含まれる $\text{NO}_x$ 等のガス状汚染物質も同時に酸化または還元して除去し、ディーゼルエンジンの排気ガスを浄化する。

【0020】

【実施例】図1はこの発明の基本概念を示す実施例1の縦断面図を示す。ディーゼルエンジンの排気ダクト2に介入してガス入口3およびガス出口4を接続したケーシング5の内部にガス流を遮る如くにセラミックフィルター6を配設する。ただし、このセラミックフィルター6は多孔質セラミックをフィルター要素とする板状、ブリーツ状、ハニカム状、円筒状等適当なあらゆる形状・構造のセラミックフィルター一般を模式的に示したもので

ある。

【0021】このセラミックフィルター6のフィルター要素7の上流側と下流側にガスの通過を許す構造の電極要素（例えば金網・金属製多孔板・金属製すだれ等）よりなる上流側プラズマ処理電極8と下流側プラズマ処理電極9を設けて、その間に交流電源10より高周波高電圧または高圧パルス電圧を連続的あるいは間欠的に印加する。

【0022】その結果両プラズマ処理電極8、9の間に、上記フィルター要素7を誘電体として介在させた放電が発生する。この放電は、該プラズマ処理電極8、9と該フィルター要素7の表面との間のガス空間では無声放電、また該フィルター要素7内部の空隙中ではボイド放電の形態をとり、いずれも電子温度は極めて高いがイオン温度は低い低温プラズマ（非平衡プラズマともいう）を生成し、酸化性および還元性の反応性に富むラジカルを豊富に作りだす。

【0023】このラジカルにより上記フィルター要素7の上流側表面および内部空隙に付着したすすは低温酸化されてCO<sub>2</sub>ないしCOとして排出され、その結果上記セラミックフィルター6のフィルター要素7は常に清浄に保たれ圧力損失を低く保つことが出来る。同時にこのラジカルによって排ガス中のNO<sub>x</sub>などのガス状汚染物質は酸化ないし還元され、除去される。

【0024】図2はすでに述べたハニカム型セラミックフィルター11の斜視図、図3はこれを用いて本発明を実施した実施例12の主要部の縦断面図である。このフィルターはハニカム構造を有し、多孔質セラミック隔壁13で隔てられた多数の細長いガス通路群14を有する。

【0025】これらのガス通路群14はその上流端と下流端において相隣る交互に上流側セラミック製閉塞部15と下流側セラミック製閉塞部16によって閉塞され、上流側に連通し下流端が閉塞された上流側ガス通路群17と、下流側に連通し上流端が閉塞された下流側ガス通路群18に分かれる。

【0026】そして排気ガスは該上流側ガス通路群17内にその上流側開口部19から進入し、上記フィルター要素7を構成する該多孔質セラミック隔壁13を通過して該下流側ガス通路群18内に入り、その下流側開口部20から排出される。すすは該セラミック隔壁13の上流側表面と、その内部空隙中に付着する。

【0027】8は上記上流側セラミック製閉塞部14の上流側にこれと接近して設けられた金網21を電極要素とする上流側プラズマ処理電極である。また9は上記下流側ガス通路群18内にその下流側開口部20から奥まで挿入された針金22を電極要素とする下流側プラズマ処理電極である。

【0028】いま両プラズマ処理電極8と9の間に交流電源10より高周波高電圧または高圧パルス電圧を連続

的あるいは間欠的に印加すると、該針金電極要素22の上流側先端部23と該金網電極要素22の間に誘電体である上記上流側セラミック製閉塞部15および該セラミック隔壁13の上流側開口部19近傍部分を介在して無声放電が発生、これにより生成したラジカルが該上流側開口部19から各上流側ガス通路群17内に進入し、該セラミック隔壁13の上流側表面とその内部空隙中に付着したすすを低温酸化して除去する。また排気ガス中の、NO<sub>x</sub>をはじめとするガス状汚染物質を酸化・還元して除去する。

【0029】図4は本発明の図3と異なる実施例24の主要部の縦断面図で、上流側プラズマ処理電極8は本実施例では針金電極要素25よりなり、その下流側先端部26が上記上流側開口部19の開口中心付近に位置する。それ以外の12から23までの要素の名称および機能は図3の実施例12における同一番号の要素と同様である。

【0030】両電極8、9の間に交流電源10より上記交流電圧を印加すると、該上流側先端部26と下流側先端部23の間に無声放電が発生してラジカルが生成、上流側開口部19付近で先ずすすの酸化がスタートし、逐次上流側ガス通路17の内部に及ぶ。その作用を助けるため、図には示されていないプラズマ処理電極8の該針金電極要素を上記上流側ガス通路17の内部に挿入し、また抽出する挿入・抽出手段があり、すすの酸化除去の進行と共に逐次該上流側先端部26を進行させ、またすすの除去がおわればこれをもとの位置に抽出する。

【0031】なおこの場合ラジカル作用でNO<sub>x</sub>を始めとするガス状汚染物質も除去されることは既に記した通りである。

【0032】図5は本発明の図3および図4と異なる実施例27の主要部の縦断面図で、上流側プラズマ処理電極8は図4と同様に針金電極要素25よりなる。しかし本実施例ではこの針金電極要素25は該上流側ガス通路群17内に奥まで上流側から挿入されており、該下流側ガス通路群18内に下流側から奥まで挿入された下流側プラズマ処理電極9の針金電極要素22と該多孔質隔壁13を介して対向している。それ以外の8から25までの要素の名称および機能は図3および図4の実施例12、24における同一番号の要素と同様である。

【0033】いま両電極8、9の間に交流電源10より上記交流電圧を供給すると、上記の両針金電極要素22、25間に該多孔質隔壁13を介して放電が発生し、該隔壁の上流側表面ならびに内部空隙内に付着したすすが除去され、かつNO<sub>x</sub>を始めとするガス状汚染物質も除去されることは既に記した通りである。

【0034】図6は本発明の図3、図4および図4と異なる実施例28の主要部の縦断面図である。本実施例では2組のプラズマ処理電極9、29のいずれもが該下流側ガス通路群18内に下流側から奥まで挿入された針金

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電極要素22および30よりなり、且つ両針金電極要素22、30はそれぞれ中間に1つの上流側ガス通路14とその両側の該多孔質セラミック隔壁13を介して対向している。それ以外の9から22までの要素の名称および機能は図3、図4およびの実施例12、24、28における同一番号の要素と同様である。

【0035】いま両プラズマ処理電極9、29の間に交流電源10より上記交流電圧を印加すると、上記両針金電極要素22、30の間に、これらに挟まれた該上流側ガス通路14とその両側の該多孔質セラミック隔壁13

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【0036】

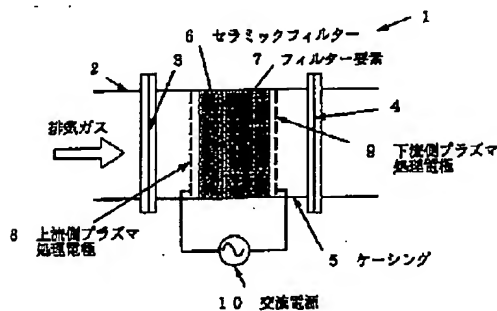
【効果】本発明は上述の通りであるので、セラミックフィルターのフィルター要素の上流側表面および内部空隙に付着したすすを放電によるプラズマ処理によって常時酸化分解し、その圧力損失のすす付着による上昇を防止してディーゼルエンジンの効率低下を防ぎ、かつセラミックフィルターの寿命を長く維持する事ができる。

【0037】また同時にディーゼルエンジン排気ガス中に含まれるNO<sub>x</sub>をはじめとするガス状汚染物質をプラズマ処理によって酸化・還元し、これを除去でき極めて経済的なディーゼルエンジン排気ガスの浄化が達成できる。

【0038】

【図面の簡単な説明】

【図1】



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【図1】この発明の基本概念を示す実施例の縦断面図である。

【図2】この発明に用いられるハニカム型セラミックフィルターの斜視図である。

【図3】この発明の別の実施例の縦断面図である。

【図4】この発明の更に別の実施例の縦断面図である。

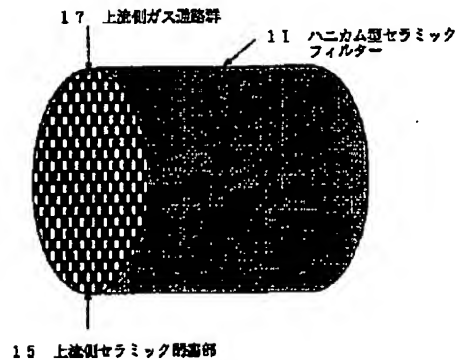
【図5】この発明の更に別の実施例の縦断面図である。

【図6】この発明の更に別の実施例の縦断面図である。

【符号の説明】

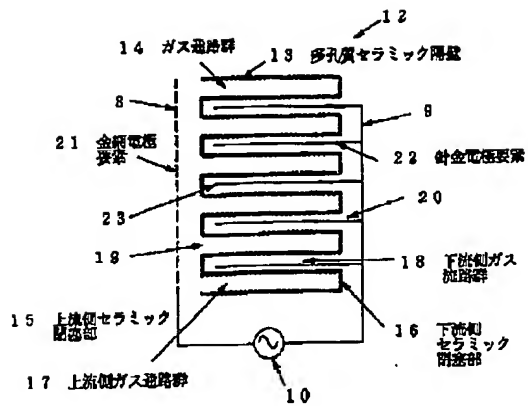
- |    |                 |
|----|-----------------|
| 2  | 排気ダクト           |
| 3  | ガス入口            |
| 4  | ガス出口            |
| 5  | ケーシング           |
| 6  | セラミックフィルター      |
| 7  | フィルター要素         |
| 8  | 上流側プラズマ処理電極     |
| 9  | 下流側プラズマ処理電極     |
| 10 | 交流電源            |
| 11 | ハニカム型セラミックフィルター |
| 13 | 多孔質セラミック隔壁      |
| 17 | 上流側ガス通路群        |
| 18 | 下流側ガス通路群        |
| 21 | 金網電極要素          |
| 22 | 針金電極要素          |
| 25 | 針金電極要素          |
| 29 | 下流側プラズマ処理電極     |

【図2】

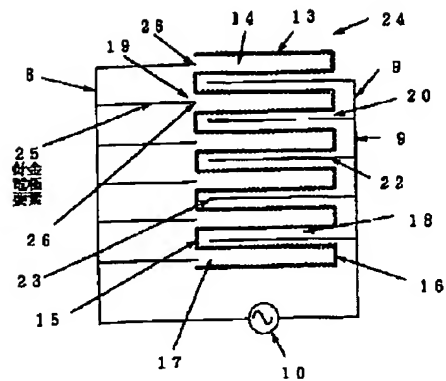


15 上流側セラミック隔壁部

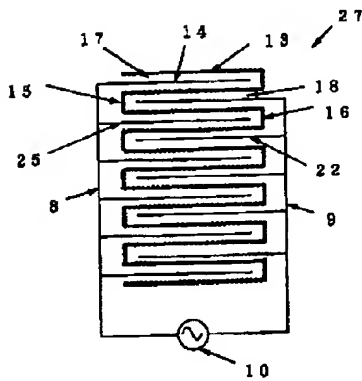
【図3】



【図4】



【図5】



【図6】

